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Abstract

PENETRATION OF THERMAL NEUTRONS IN CYLINDRICAL DUCTS THROUGH
HYDROGENOUS MEDIA

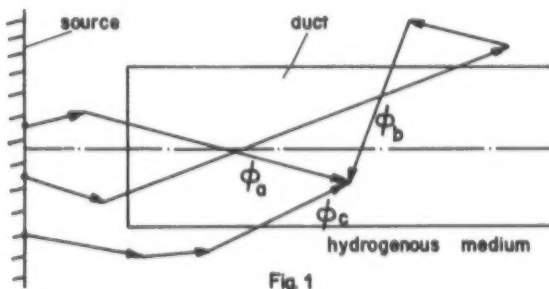
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This paper presents an attempt to fill the gap between simple methods of thermal flux evaluation in straight ducts [1] giving generally poor results and prohibitively time consuming Monte Carlo calculations.

A method for the determination of the thermal neutron flux in a duct, due to neutrons of all energies emitted by a plane source perpendicular to the axis of the duct (Fig. 1), is elaborated.

The thermal flux in the duct is divided into three components (Fig. 1):

- a) direct component Φ_a ,
- b) reflected component Φ_b ,
- c) leakage component Φ_c .



The determination of the first component presents no difficulty. The main problem concerns the determination of the other components.

The method is based on the application of transport theory inside the duct and two-group diffusion theory in the medium surrounding the duct. The connection between these theories is effected by a proper choice of angular distributions for the neutrons entering the duct.

It is assumed that there is equilibrium between fast and thermal fluxes in the neighbourhood of the duct implying a sufficient hydrogen content in the medium. This assumption introduces a major simplification in the method by allowing the calculations to be made for the thermal group only.

The boundary condition at the duct's wall is satisfied by performing accurate book-keeping of neutrons at each point taking account of multiple reflection of neutrons by the medium surrounding the duct. This leads us to an integral equation of the Fredholm type, the solution of which constitutes the most important part of the numerical effort.

As an example the method is applied to the case of ducts through water.

In order to check the validity of this method, thermal neutron flux measurements by dysprosium foils are performed in tightly sealed plexiglas tubes immersed in the pool of the swimming pool reactor SAPHIR [2] using the core of the reactor as the neutron source.

The comparison between the calculated and the measured fluxes in two ducts of different dimensions shows that the theoretical results are in a very good agreement with the experimental results. The maximum relative deviation for a duct 250 cm in length by 12.5 cm in diameter is 14% and for a duct 170 cm in length by 5.9 cm in diameter is 22%. The maximum neutron flux attenuations in the ducts are respectively $6 \cdot 10^{-4}$ and $2 \cdot 10^{-4}$.

[1] Formulaire sur le calcul de la protection des réacteurs, Rapport C.E.A. No. 2253, 1963

[2] F. Alder et al., "Description of the Swiss Research Reactors", RAG-Bericht Nr. 2, 1957